

ORIGINAL ARTICLE

ENDODONTIC TREATMENT OUTCOME BETWEEN NICKEL-TITANIUM ROTARY AND STAINLESS STEEL HAND FILING TECHNIQUES: A RETROSPECTIVE STUDY

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ABSTRACT:

Background: In the endodontic therapy, the success of treatment depends solely on the endodontic triad, “diagnosis + anatomy +debridement =success”. Successful treatment depends on the debridement of the canal system with proper cleaning and shaping of canals being of utmost importance. So, we planned this study to evaluate the periapical healing and the incidence of procedural errors of molar teeth treated endodontically using a rotary technique as compared with manual preparation with stainless steel hand files.

Materials and Methods: From the computerized hospital database, there were 973 primary (ie, first-time treatment, all retreatments excluded) nonsurgical root canal treatments completed for both maxillary and mandibular first and second permanent molars. Of these, 126 cases were randomly selected and constituted the group for which root canal instrumentation was performed by hand with a filing technique using stainless steel instruments (group 1). There were 973 primary endodontic treatments completed for the maxillary and mandibular first and second molars. A random Selection of 138 records were retrieved and checked to confirm that Root canal preparation had indeed been performed with the hybrid rotary technique using NiTi (continuous reaming by hand or engine Driven) instruments (group 2). All treatment records were examined in detail. **Results:** A total of 264 molars in 227 patients were examined; all of them had received treatment from a dental undergraduate or postgraduate student. Of all 225 teeth analyzed, totally, n=67 were deemed to be a failure to heal, whereas n = 197 showed complete resolution or definitive sign of healing. The group 2 was associated with a significantly higher rate of favorable/complete healing (p < 0.05, chi-square test) and lesser amount of procedural errors (p < 0.05, Mann-Whitney test) than the group 1. **Conclusion:** Within the limitation of this study, we would conclude that NiTi instrument should be the choice for preparing root canals in primary endodontic treatment, especially for inexperienced operator and teeth with preoperative radiolucent lesions.

Keywords: Apical periodontitis, complications, failure, ledging, nickel-titanium instruments, periapical healing, procedural errors.

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INTRODUCTION:

In the endodontic therapy, the success of treatment depends solely on the endodontic triad, “diagnosis + anatomy +debridement =success”. Successful treatment depends on the debridement of the canal system with proper cleaning and shaping of canals being of utmost importance.¹ Hatton et al (1928)² reported that canals prepared with stainless steel instruments were only superficially cleaned and much of the pulp tissue was not removed. Stainless steel files have also been shown to create aberrations, probably as a result of the inherent stiffness of stainless steel, which is compounded by instrument design and canal shape.³ Weine et al (1975)⁴ reported that most instrumentation techniques with stainless steel instruments in curved canals result in apical transportation. This makes obtaining a successful apical seal more difficult.

A new generation of endodontic instruments has been developed from nickel-titanium alloy that potentially allows shaping of narrow, curved root canals, without causing aberrations.³ According to Serene et al (1995)⁵ the

nickel titanium alloys exhibit superelastic behavior and a shape memory effect. Another important aspect of biomechanical preparation is the shape of the root canals. Round preparations have been advocated to allow better adaptation of the obturation material resulting in a better seal.⁶

Although studies have shown the superiority of rotary over manual instrumentation in terms of the shaping ability and efficiency in a clinical setting.^{2,7,8} There are few reports of the effect of NiTi rotary instrumentation on the treatment outcome. One study showed that periapical healing of teeth treated by way of manual instrumentation (stainless steel K files) was comparable to that using ProFile (engine files); the result was based on a total of 66 patients, a sample size that might be too small to show a difference.⁹ Another report indicated that the overall success rate of endodontic treatment was about 86% with the use of rotary instruments (ProFilevs GT Rotary [Dentsply Tulsa] vs Lightspeed) with no significant difference between brands¹⁰; however, a group of manual instrumentation was not included for comparison. So, we planned this study to evaluate the

periapical healing and the incidence of procedural errors of molar teeth treated endodontically using a rotary technique as compared with manual preparation with stainless steel hand files.

MATERIALS AND METHODS

The study was conducted in the department of conservative dentistry and endodontics in the institution. From the computerized hospital database, there were 973 primary (ie, first-time treatment, all retreatments excluded) nonsurgical root canal treatments completed for both maxillary and mandibular first and second permanent molars. Of these, 126 cases were randomly selected and constituted the group for which root canal instrumentation was performed by hand with a filing technique using stainless steel instruments (group 1). There were 973 primary endodontic treatments completed for the maxillary and mandibular first and second molars. A random selection of 138 records were retrieved and checked to confirm that

Root canal preparation had indeed been performed with the hybrid rotary technique using niti (continuous reaming by hand or engine driven) instruments (group 2). All treatment records were examined in detail. Demographic data and information related to the treatment were obtained. Five types of procedural errors, if any, were identified by noting the entries in the record and from the radiographic appearance of the root canal fillings: ledging, perforation (lateral or strip perforation), apical transportation, stripping (but not perforated), and fractured instrument. Any attempt by the operator at that time to correct the error(s) before obturation was also noted.

All selected patients were then invited to return for a recall during which clinical and radiographic (paralleling technique) examination of the tooth were performed. Radiographs were evaluated by a precalibrated examiner. The treatment outcome was classified into three categories: (1) “favorable,” when there were no signs or symptoms associated with the tooth and no periapical rarefaction (or with an obvious diminishing periapical rarefaction if the observation time was less than 4 years duration); (2) “uncertain,” when a preexisting periapical rarefaction showed no discernible change in size (only for those with an observational period shorter than 4 years that remained asymptomatic), and (3) “failure to heal,” when the tooth

was associated with a newly developed or an enlarging periapical lesion or with a radiolucent area of any size for 4 years or more after treatment. The treatment was also deemed to be a failure if the tooth was symptomatic at recall, regardless of the radiographic appearance. All data, including intraoperative covariables, treatment outcome, and the incidence of procedural errors were entered into a spreadsheet and analyzed in software (SPSS Version 16.0). The associations of both the healing outcome and the (incidence of) procedural errors with various factors for the two instrumentation groups were examined in a univariate test (Mann-Whitney or chi-square where appropriate).

RESULTS:

A total of 264 molars in 227 patients were examined; all of them had received treatment from a dental undergraduate or postgraduate student. Of all 225 teeth analyzed, totally, n=67 were deemed to be a failure to heal, whereas n = 197 showed complete resolution or definitive sign of healing (Tables 1). The group 2 was associated with a significantly higher rate of favorable/complete healing (p < 0.05, chi-square test) and lesser amount of procedural errors (p < 0.05, Mann-Whitney test) than the group 1 (Tables 1 and 2). NiTi instruments generally produced significantly fewer procedural errors than stainless steel hand files (Table 1 and 2). The distribution of the various forms of procedural error in either group was not normally distributed, and, thus, the Mann-Whitney test was used to compare their incidence between groups. There was a significant difference between the group 1 and 2 in the amount of ledging and perforation produced (p < 0.05) (figure 1 and 2) but not for stripping, apical transportation, or instrument separation. When the two forms of procedural error (ledging and perforation) were entered into the stepwise logistic regression analysis, only “ledging” was found to have a significant negative impact on the treatment outcome. Other factors that had a significant influence on the treatment outcome included the time of recall (greater chance of failure for longer observation period), operator (with postgraduate producing a greater amount of favorable outcome than undergraduate students), dental arch (reduced chance of failure for maxillary molars), and instrumentation method (rotary instrumentation being more favorable), and the presence of a preoperative radiolucent lesion (being more prone to failure).

Table 1: Healing outcomes for the instrumentation in Group 1: Incidence of procedural errors

Type of error	Favorable	Uncertain	Failure	Subtotal
Ledging*	0.29(0.48)	0.68(0.55)	0.56(0.54)	0.33(0.45)
Stripping	0.03(0.14)	0.00(0.00)	0.00(0.00)	0.02(0.16)
Apical transportation	0.04(0.19)	0.00(0.00)	0.07(0.19)	0.05(0.16)
Perforation*	0.03(0.15)	0.00(0.00)	0.10(0.31)	0.06(0.22)
Fractured instruments	0.03(0.18)	0.00(0.00)	0.11(0.31)	0.03(0.11)
Overall	N=53 out of 126 endodontically treated teeth			

Table 2: Healing Outcomes For The Instrumentation In Group 2 : Incidence Of Procedural Errors

Type of error	Favorable	Uncertain	Failure	Subtotal
Ledging*	0.18(0.40)	0.17(0.28)	0.23(0.44)	0.18(0.39)
Stripping	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Apical transportation	0.04(0.22)	0.00(0.00)	0.09(0.29)	0.06(0.21)
Perforation*	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Fractured instruments	0.03(0.15)	0.18(0.42)	0.09(0.32)	0.06(0.19)
Overall	N=35 out of 138 endodontically treated teeth			

Figure 1: Comparison of incidence of ledging in group 1 and 2

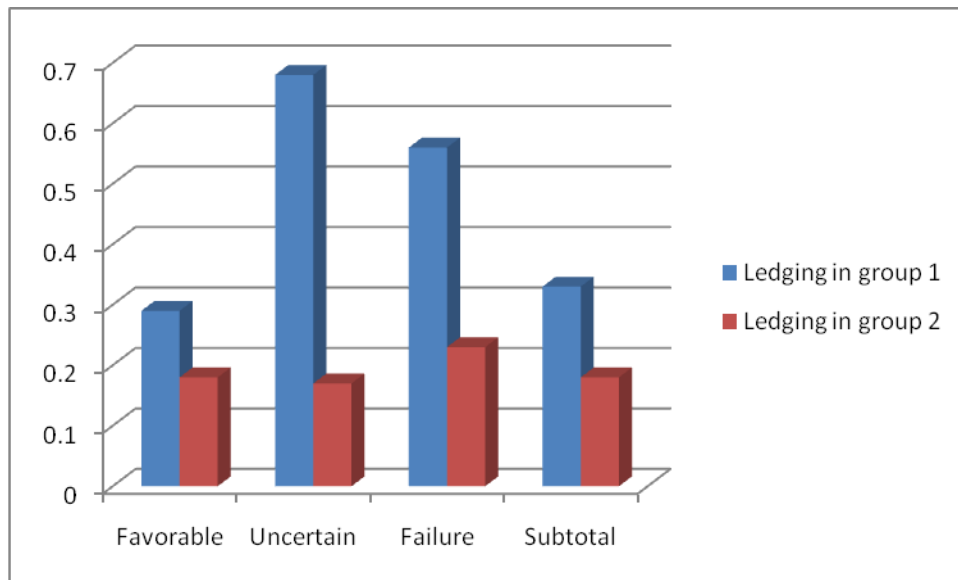
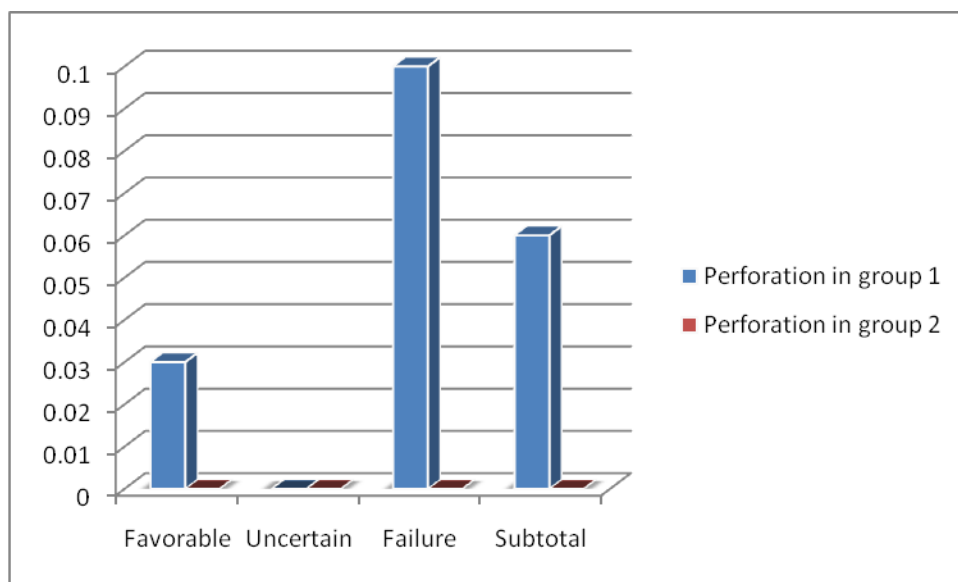


Figure 2: Comparison of incidence of perforation in group 1 and 2



DISCUSSION:

In this study, the teeth were examined clinically, and the presence of any symptoms was considered as a failure of the periapical tissue to heal, regardless of the radiographic status. A set of published guidelines has suggested that to qualify an endodontically treated tooth for success periapical healing must have been completed within 4 years after root canal treatment.¹¹ Arguably, a 4-year cutoff period may not be appropriate for all cases because healing could still continue beyond that period.¹² Thus, a study using such strict criteria might have overstated the failure rate. On the other hand, as we have classified some diminishing (in size) radiolucent areas as a “favorable” outcome, it is possible for our result to understate the amount of failures. In fact, the result of logistic regression indicated a slight increase in the chance of failure (odds ratio = 1.03) for lengthier recall periods. A similar trend of a declining survival has been reported for the initial period, up to about 5 years, after nonsurgical root canal treatment.^{13, 14}

Guelzow A, Stamm O et al. compared *ex vivo* various parameters of root canal preparation using a manual technique and six different rotary nickel-titanium (Ni-Ti) instruments (flexmaster, System GT, HERO 642, K3, protaper, and Race). A total of 147 extracted mandibular molars were divided into seven groups with equal mean mesio-buccal root canal curvatures (up to 70), and embedded in a muffle system. All root canals were prepared to size 30 using a crown-down preparation technique for the rotary nickel-titanium instruments and a standardized preparation (using reamers and Hedstrom files) for the manual technique. Length modifications and straightening were determined by standardized radiography and a computer-aided difference measurement for every instrument system. Post-operative cross-sections were evaluated by light-microscopic investigation and photographic documentation. Procedural errors, working time and time for instrumentation were recorded. The data were analysed statistically using the Kruskal-Wallis test and the Mann-Whitney test. No significant differences were detected between the rotary Ni-Ti instruments for alteration of working length. All Ni-Ti systems maintained the original curvature well, with minor mean degrees of straightening ranging from 0.45 to 1.17 (protaper). Protaper had the lowest numbers of irregular post-operative root canal diameters; the results were comparable between the other systems. Instrument fractures occurred with protaper in three root canals, whilst preparation with System GT, HERO 642, K3 and the manual technique resulted in one fracture each. Ni-Ti instruments prepared canals more rapidly than the manual technique. The shortest time for instrumentation was achieved with System GT (11.7 s). It was concluded that under the conditions of this *ex vivo* study all Ni-Ti systems maintained the canal curvature,

were associated with few instrument fractures and were more rapid than a standardized manual technique. Protaper instruments created more regular canal diameters.¹⁵ Sang Won Kwak et al. conducted a study aimed to compare two nickel-titanium systems (rotary vs. reciprocating) for their acceptance by undergraduate students who experienced nickel-titanium (NiTi) instruments for the first time. Eighty-one sophomore dental students were first taught on manual root canal preparation with stainless-steel files. After that, they were instructed on the use of ProTaper Universal system (PTU, Dentsply Maillefer), then the WaveOne (WO, Dentsply Maillefer). They practiced with each system on 2 extracted molars, before using those files to shape the buccal or mesial canals of additional first molars. A questionnaire was completed after using each file system, seeking students' perception about 'Ease of use', 'Flexibility', 'Cutting-efficiency', 'Screwing-effect', 'Feeling-safety', and 'Instrumentation-time' of the NiTi files, relative to stainless-steel instrumentation, on a 5-point Likert-type scale. They were also requested to indicate their preference between the two systems. Data was compared between groups using t-test, and with Chi-square test for correlation of each perception value with the preferred choice ($p = 0.05$). Among the 81 students, 55 indicated their preferred file system as WO and 22 as PTU. All scores were greater than 4 (better) for both systems, compared with stainless-steel files, except for 'Screwing-effect' for PTU. The scores for WO in the categories of 'Flexibility', 'Screwing-effect', and 'Feeling-safety' were significantly higher scores than those of PTU. A significant association between the 'Screwing-effect' and students' preference for WO was observed. Novice operators preferred nickel-titanium instruments to stainless-steel, and majority of them opted for reciprocating file instead of continuous rotating system.¹⁶

Only maxillary and mandibular molars were selected as the sample for this study because previous reports have indicated that this group of teeth are most likely to fail after primary root canal treatment, especially when strict criteria are adopted and the whole tooth (instead of individual roots) is regarded as the unit of measure.^{13, 14} Any means to improve the treatment outcome for molars is likely to benefit other tooth types as well. Considered separately, a significantly higher healing rate was observed for maxillary than mandibular molars (81% vs 61%, odds ratio = 0.31 for a lower chance of failure in the maxilla). The reduced success rate for mandibular molars may partly be explained by their complex anatomy, especially for the second molar. The C shaped root canal system is a common occurrence among the local population; the incidence was estimated to be about 30% or higher. This canal anatomy is a challenge to effective endodontic therapy.¹⁷⁻¹⁹ Unfortunately, the presence of a C-shaped root canal anatomy was not routinely entered in the treatment record at that time, and,

hence, the exact number was not available. Clinical accessibility, especially for the mesial canals of lower molars, might be another factor leading to a reduced success rate.

M. Locke et al. assessed adoption of endodontic nickel-titanium (NiTi) rotary technology by general dental practitioners and identified factors influencing its uptake. General dental practitioners (n = 584) were approached regarding their usage or otherwise of nickel-titanium rotary instrumentation during root canal shaping. The postal questionnaire took the form of an anonymous survey comprising 13 questions. These questions covered usage parameters, satisfaction, training issues and reasons for avoidance of NiTi instruments. The response rate was 71%. Nickel-titanium rotary instruments were used routinely by 67% of those responding practitioners. Principle factors cited as being implicated in the decision to not adopt NiTi use included cost (65% of responses), lack of training and the perceived risk of instrument fracture. It was concluded that over two thirds of dental practitioners in Wales use rotary NiTi endodontic technology with the majority having converted to such systems more than three years ago. There was, however, a significant disparity in NiTi usage between solely NHS practitioners (42%) and private practitioners (90%). Continued provision of high quality hands-on practical workshops may be of benefit in facilitating a positive initial NiTi experience in order to assist the transfer to these newer technologies.²⁰

This study is a retrospective cohort study in which there were some uncontrolled variables, such as the operator skill and type and function of the final restoration. Radiographic interpretation can also be a source of errors. The instrumentation technique used was not the same as the one recommended by the manufacturer. Instead, a continuous reaming motion was used for a hand-operated NiTi instrument (Thermafil Verifier). Although this may be regarded as a ProFile 0.04 engine file used in an extremely low rotation rate, our results here may only be applicable to the hybrid technique described. Admittedly, a randomized controlled clinical trial would be ideal for comparing the effect of the rotary versus manual instrumentation and, perhaps, the difference among various brands of rotary instrument on the treatment outcome.

CONCLUSION:

Nonetheless, an association between rotary (continuous reaming) instrumentation and a lower incidence of procedural errors as well as a better treatment outcome is clearly shown for NiTi instruments. Within the limitation of this study, we would conclude that NiTi instruments should be the choice for preparing root canals in primary endodontic treatment, especially for inexperienced operator and teeth with preoperative radiolucent lesions.

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